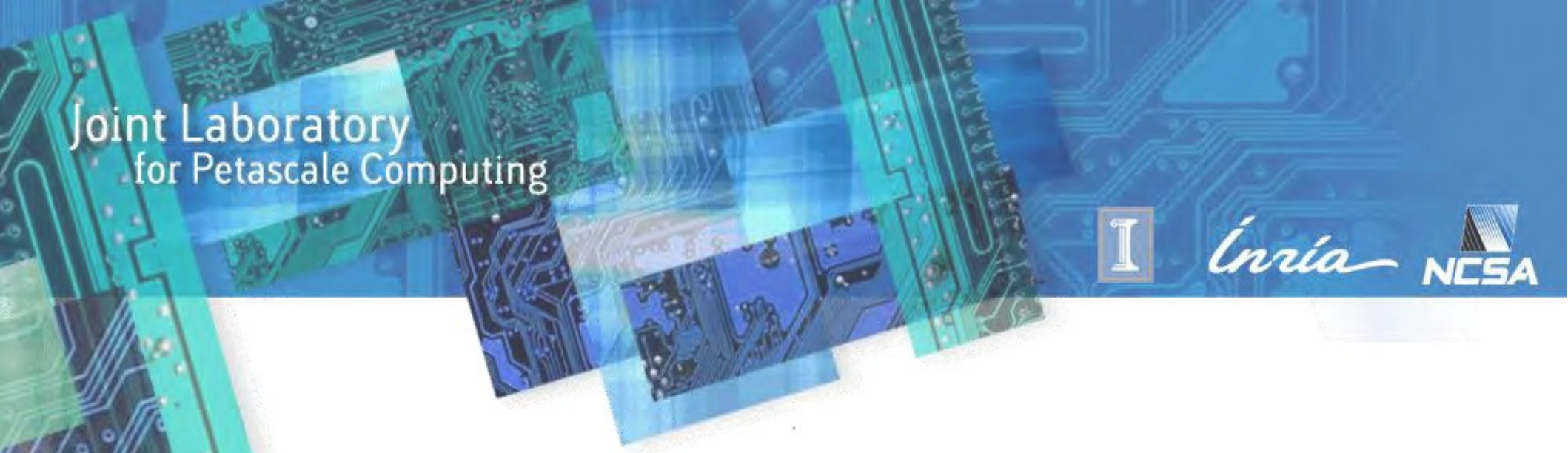
Towards Smart Visualization Framework for Climate Simulations

Lokman Rahmani, Matthieu Dorier, Luc Bougé, Gabriel Antoniu, Robert Sisneros, Tom Peterka



Towards Smart Visualization Framework for Climate Simulations

Lokman Rahmani, Matthieu Dorier, Luc Bougé — ENS Rennes, IRISA
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Tom Peterka — Argonne National Laboratory

Outline

1. HPC Climate Simulations & In Situ Visualization
2. Smart In Situ Visualization
3. Experimental Results
4. Conclusion

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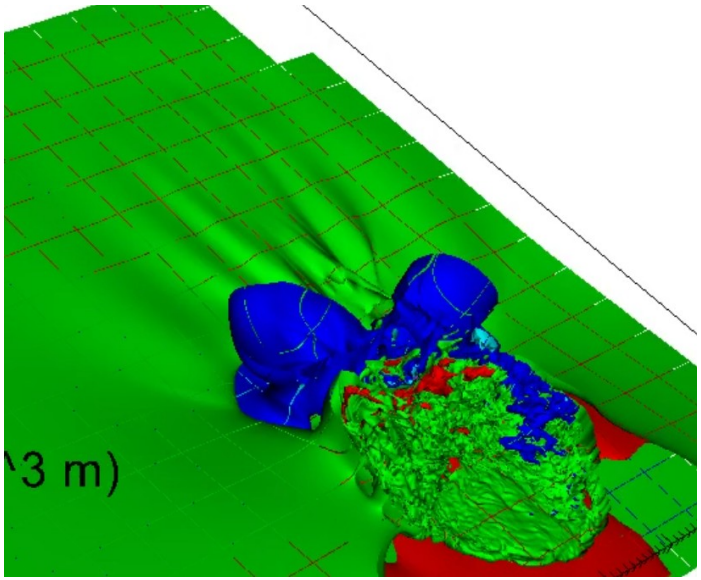
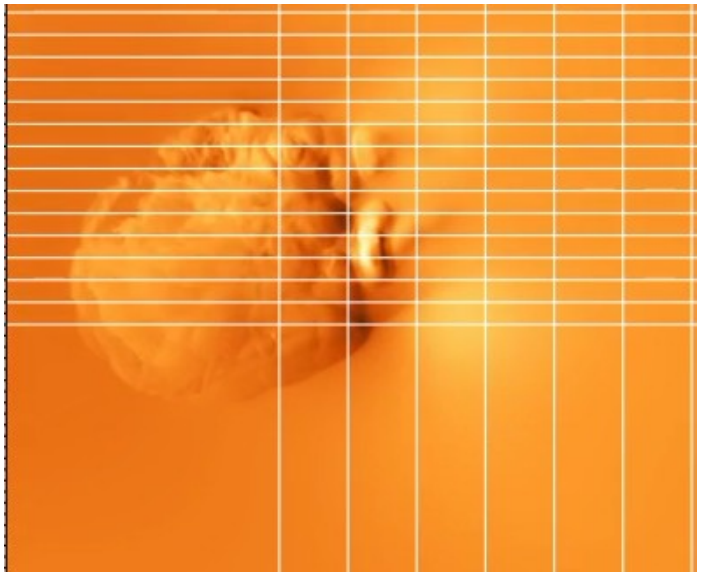
CM1 : Atmospheric Phenomena Simulation

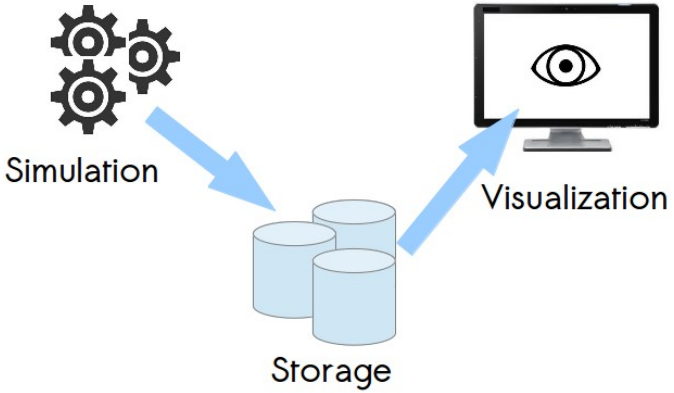
- CM1 on Kraken
  - Simulated space : 48 x 44 x 200 per process
  - 9216 cores
  - 14.2 GBytes/Iteration (~1.69 MBytes for each compute process)
- CM1 on BlueWaters
  - Simulated space : 3840 x 3840 x 400
  - 6400 cores
  - 23.6 GBytes/Iteration (~3.7 MBytes for each process)



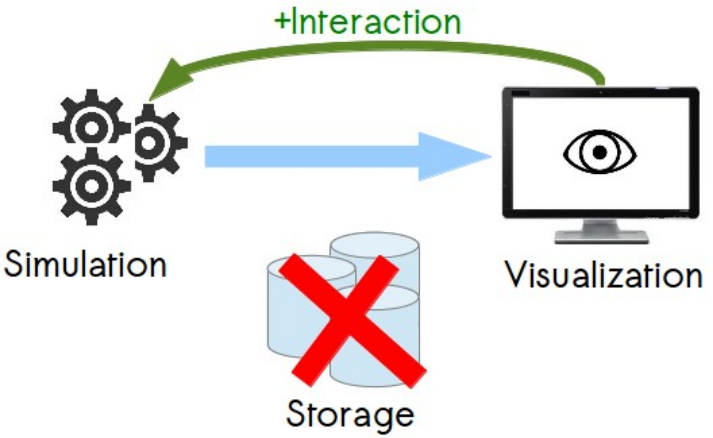


In Situ Visualization

Off-line



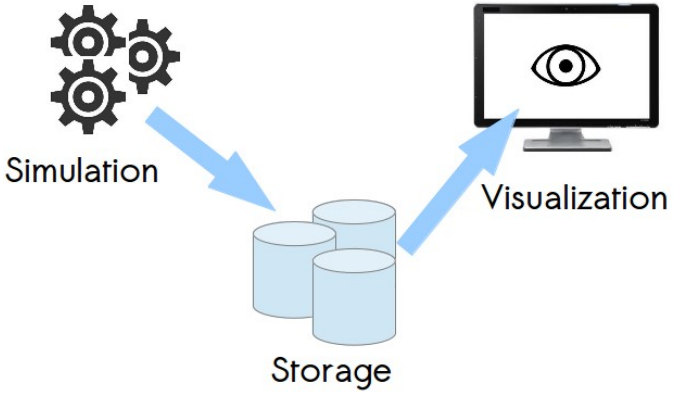
In Situ



In Situ Visualization Workflow

In Situ Visualization

Off-line



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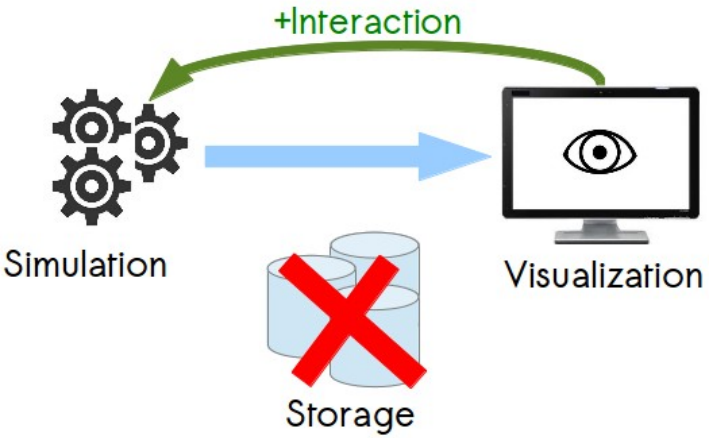

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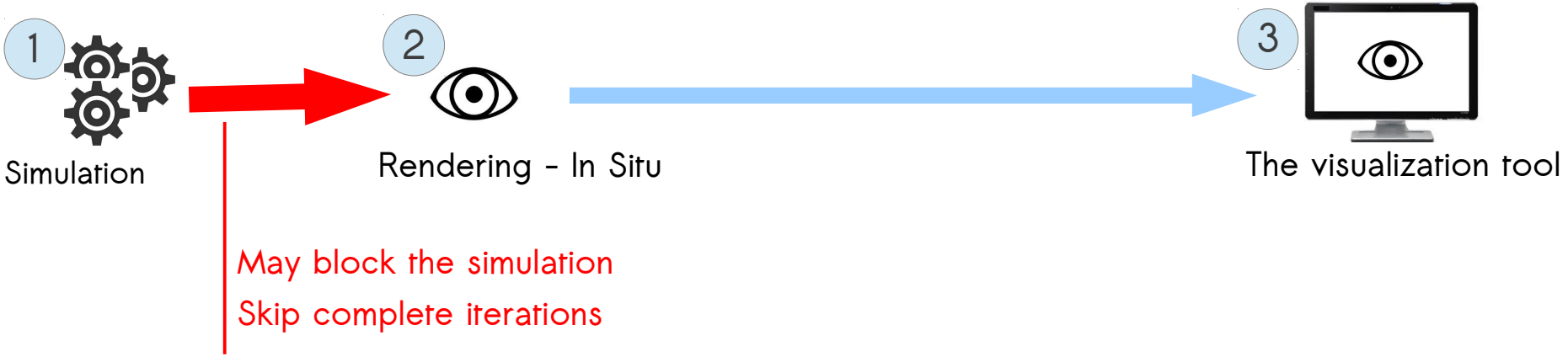

In Situ Visualization

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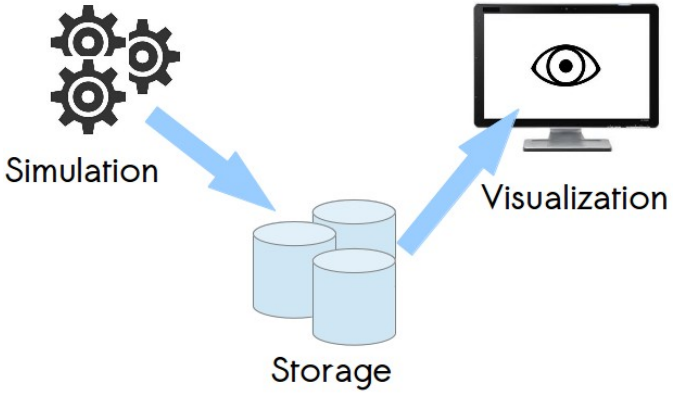

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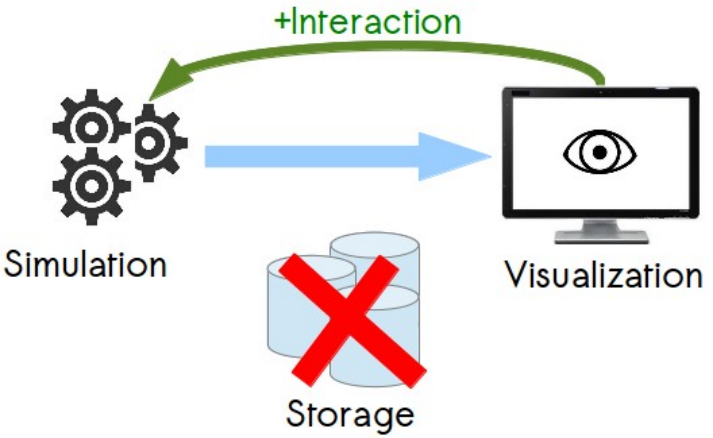
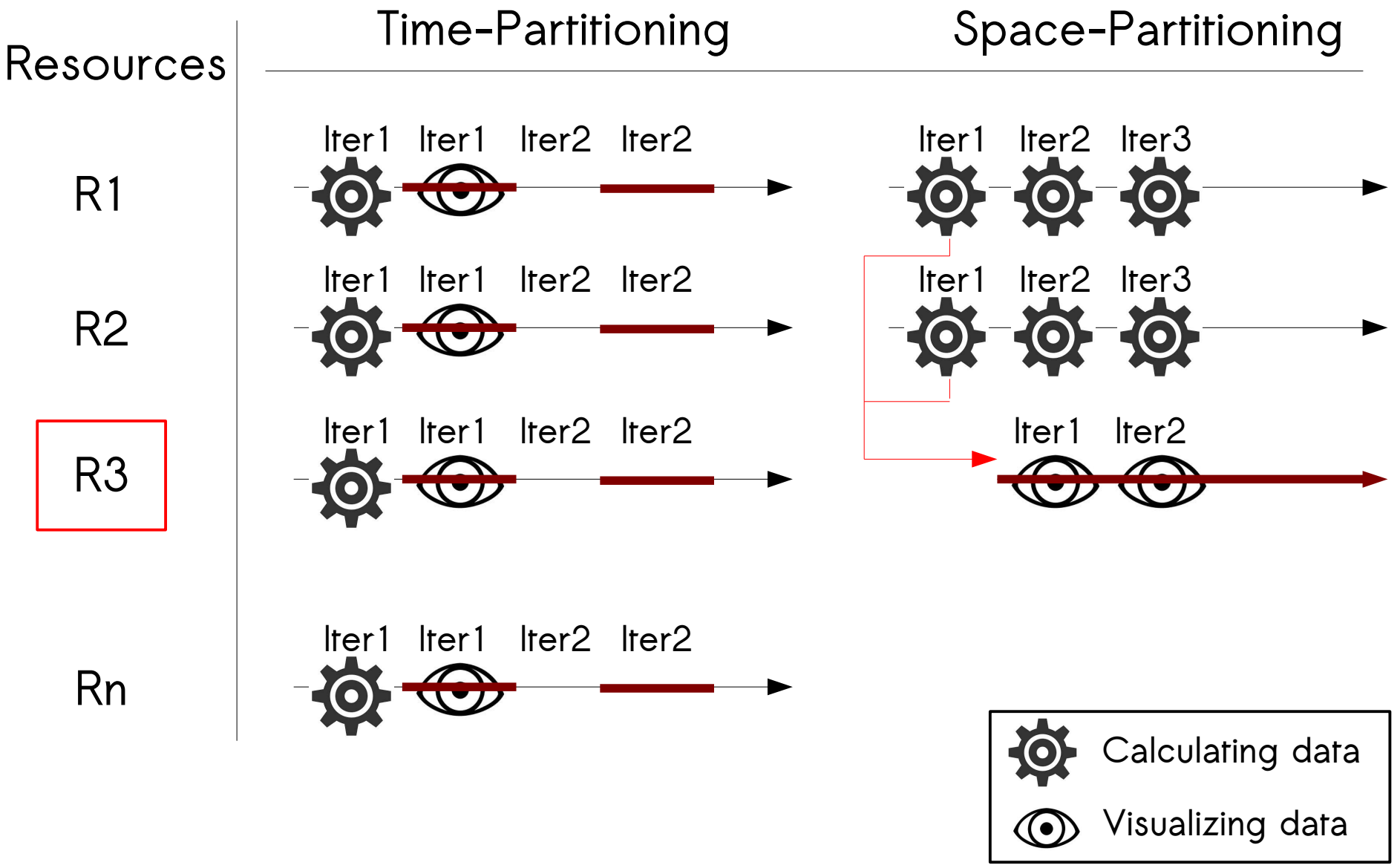


In Situ Visualization Workflow

Avoid blind drop of data

In Situ Visualization Implementation



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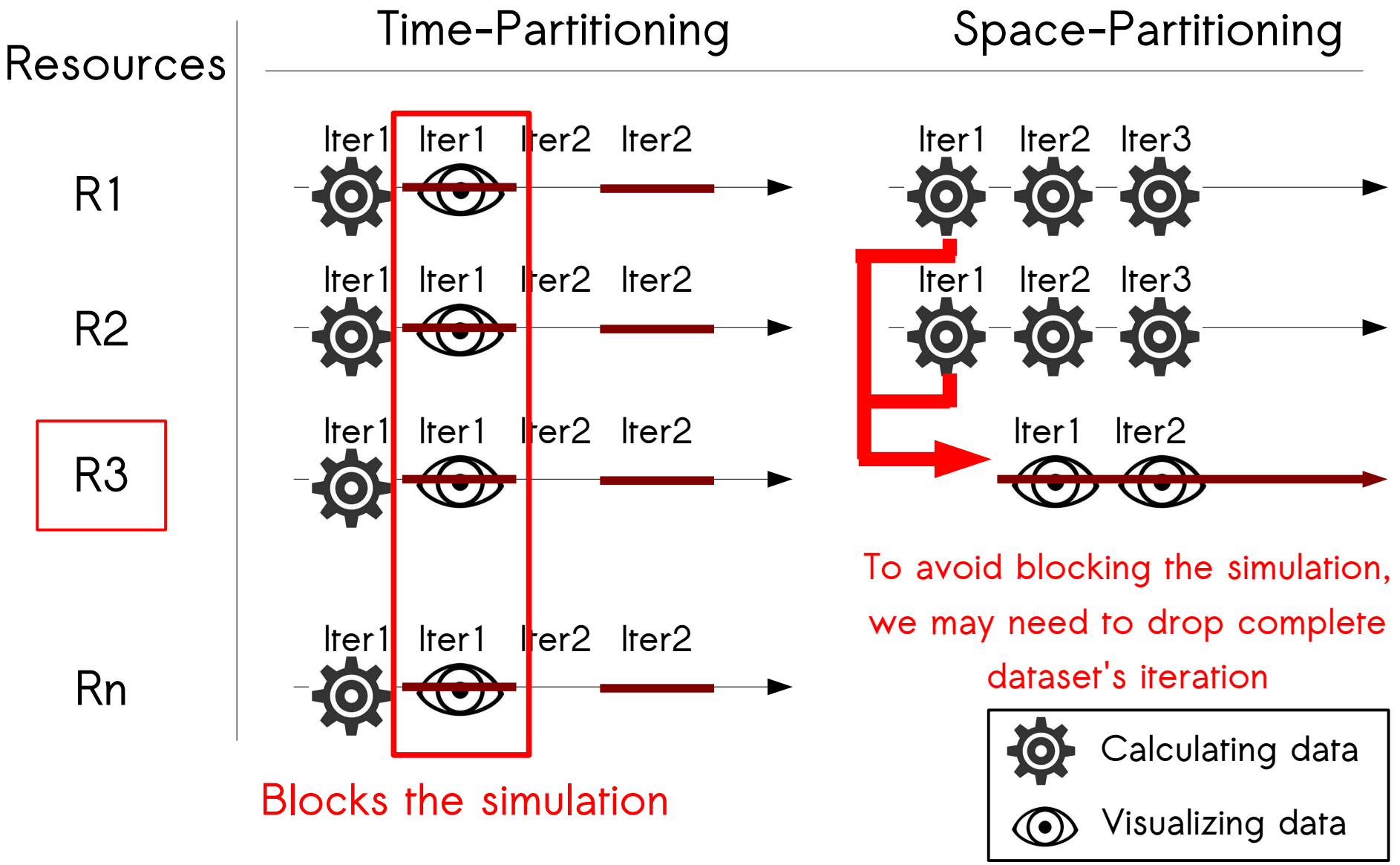

Be Smart, Visualize only relevant data

- Avoid blind drop of data
  - Keep all iterations
  - Reduce the amount of data on each iteration
- On each iteration, visualize only relevant data considering the physical phenomena being simulated
  - Interesting data will be visualized in full resolution
  - The rest will be visualized in low resolution

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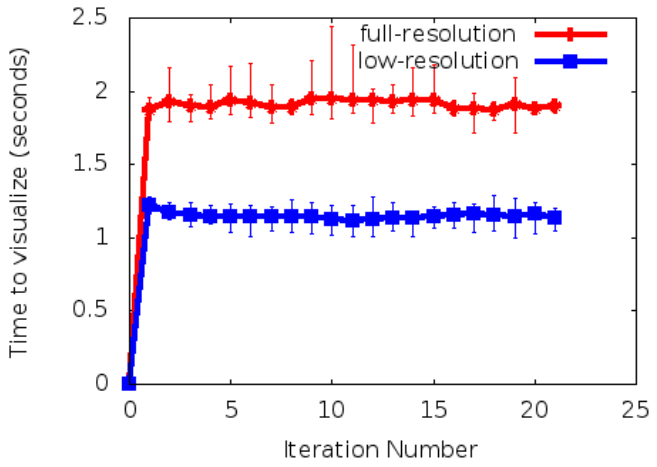

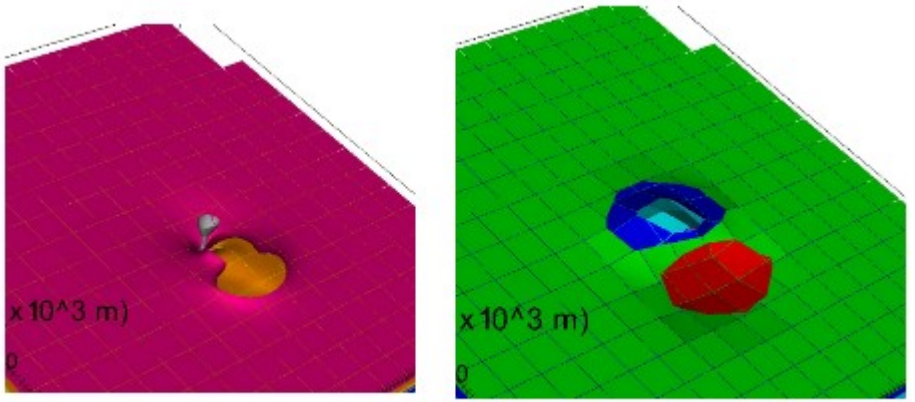

(a) Full resolution

(b) Low resolution

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What is 'relevant' data?

and

how to detect it?

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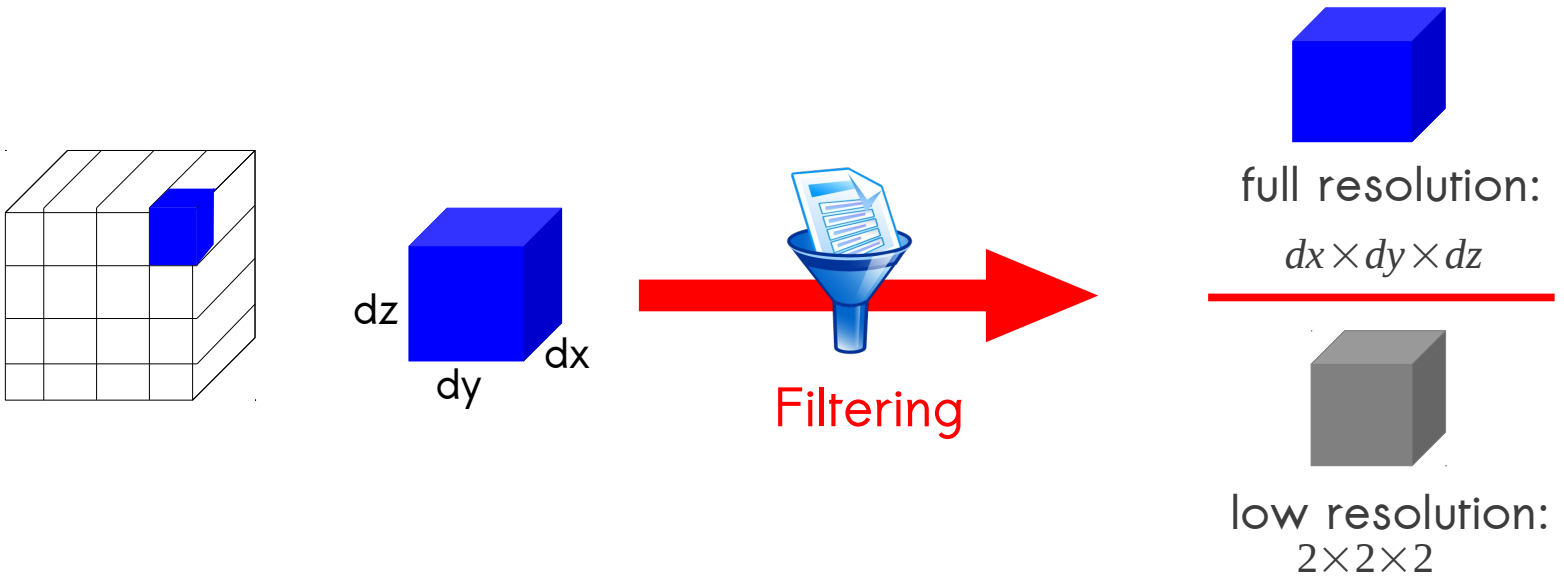
What is Relevant in a Dataset?

- The solution needs to be:
  - Generic: application-independent
  - Automatic: user-transparent
  - Efficient
- Defined semantic : Variation of the data

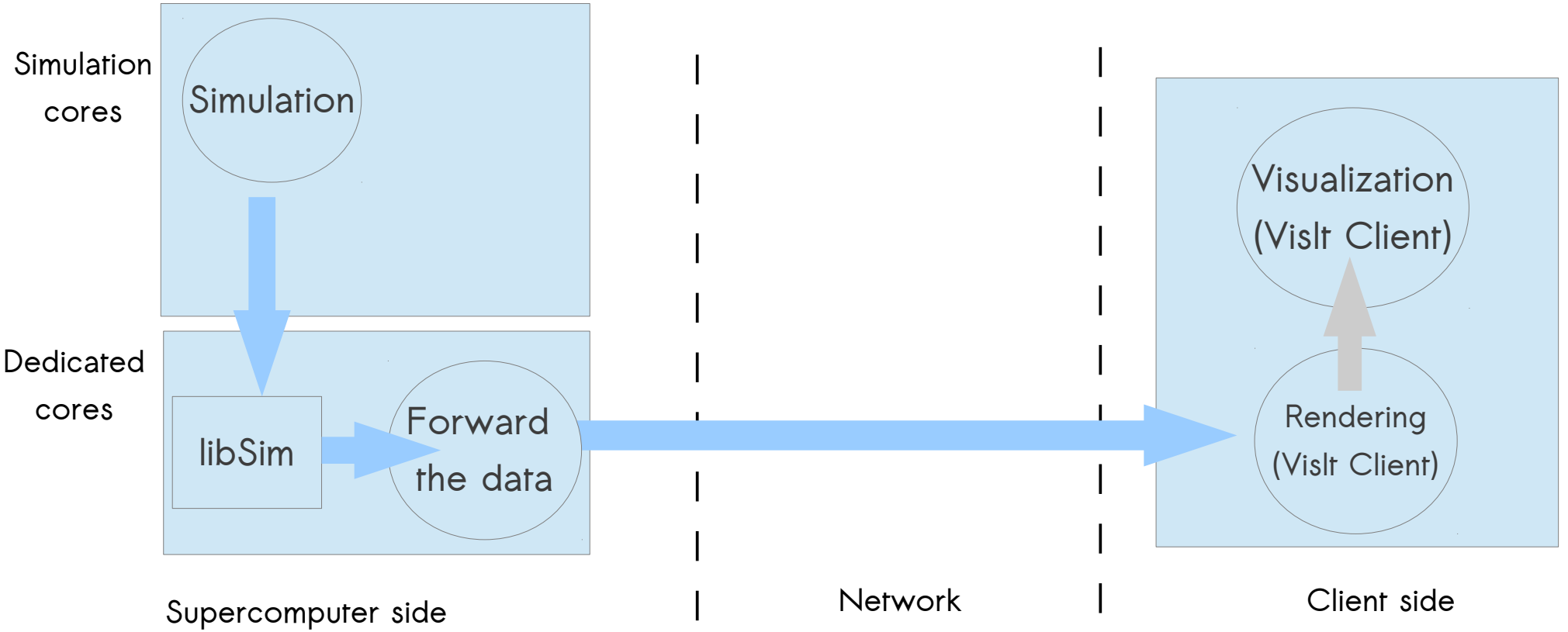


How to Automatically Detect Relevant Data?

- Metrics used to do filtering should :
  - Provide different levels of variation measurement
  - Can be 'normalized'
- To detect variation in χ, a set of values $\{x1, x2, \ldots, xn\}$
  - Entropy (Information Theory) : of a random variable $\mathbf{X}$
  - Coefficient of Variation (Statistics) $C_v = \frac{\sigma}{\mu}$
    - Independent from the unit of measurement
    - Hard to normalize
  - Gradient (Image Processing)
    - Calculate the derivate over each axis
    - Is not a complete metric

Integration int Existing ISV Frameworks

- Damaris/Viz ISV framework:
  - Damaris : I/O framework
  - VisIt : Client-Server visualization tool



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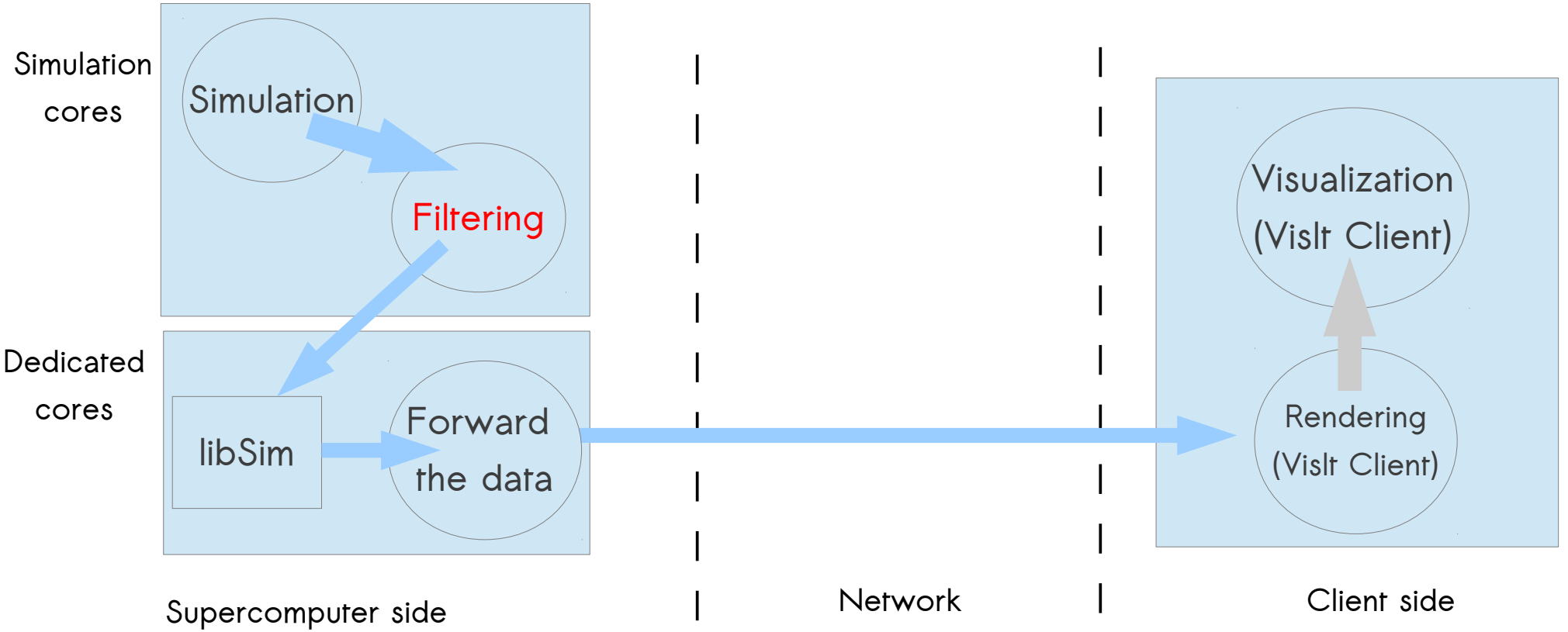

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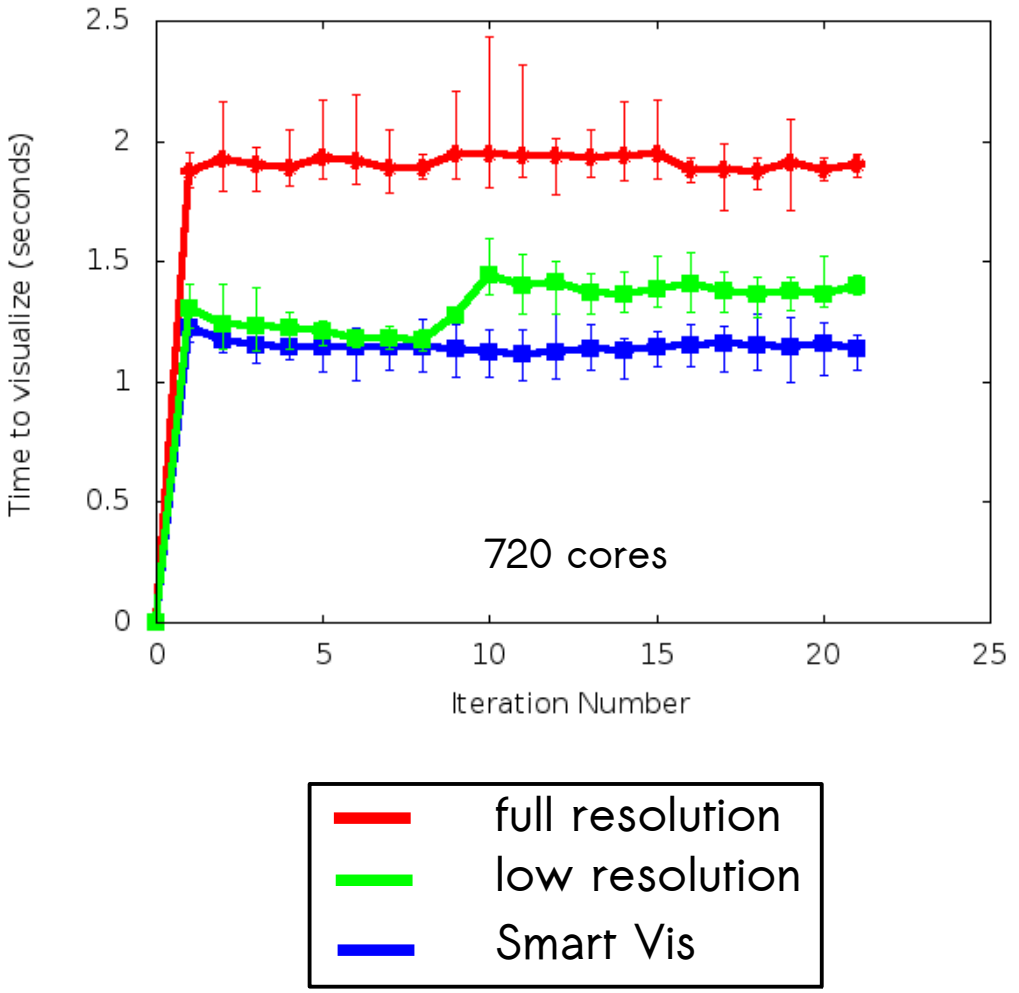
CM1 on Grid5000

- CM1 on Reims cluster:
  - 30 nodes, 24 cores each
  - 1Gbits/s Ethernet



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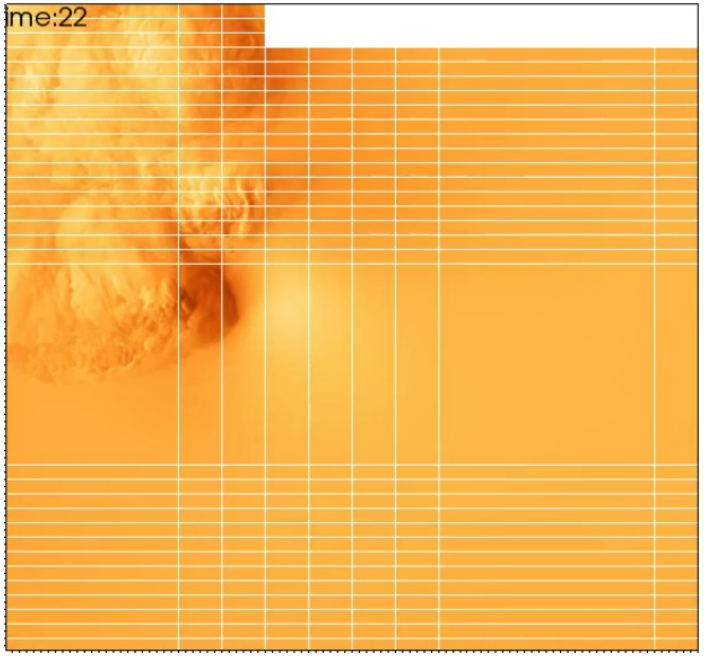

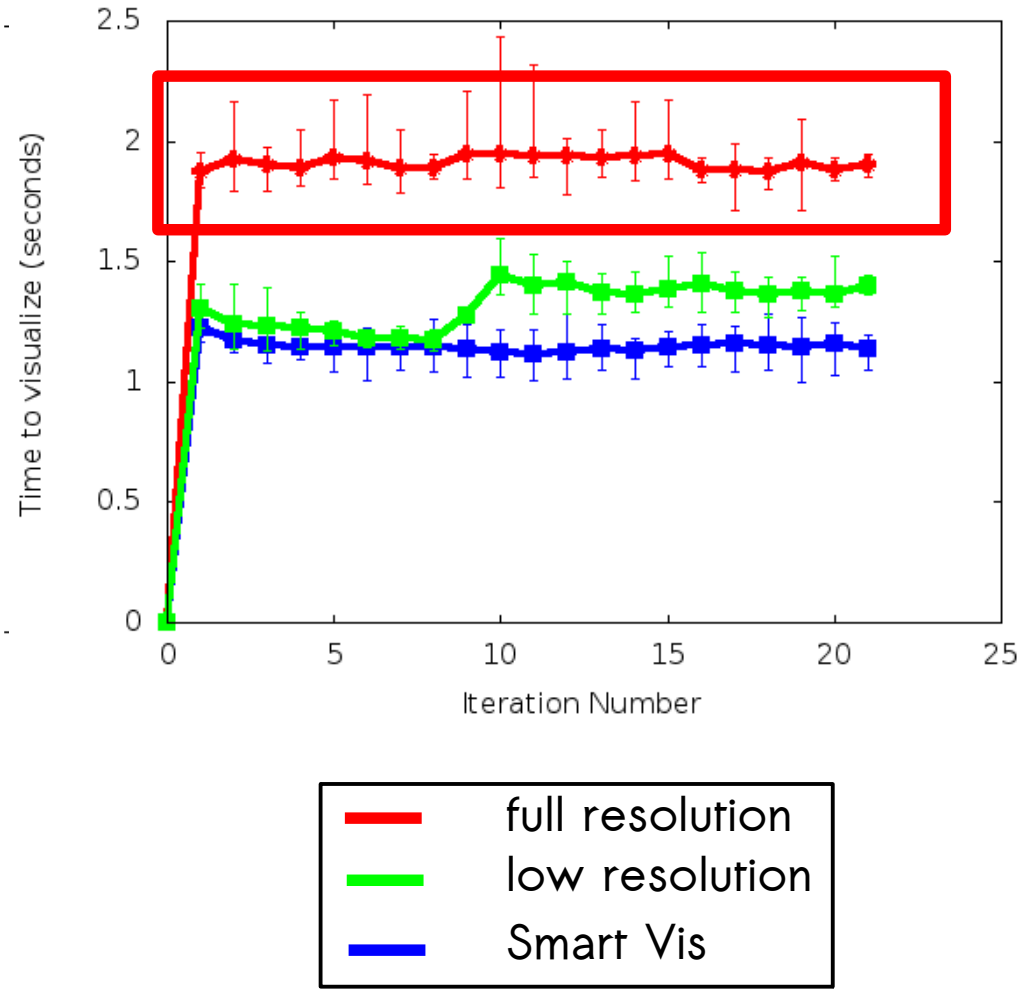

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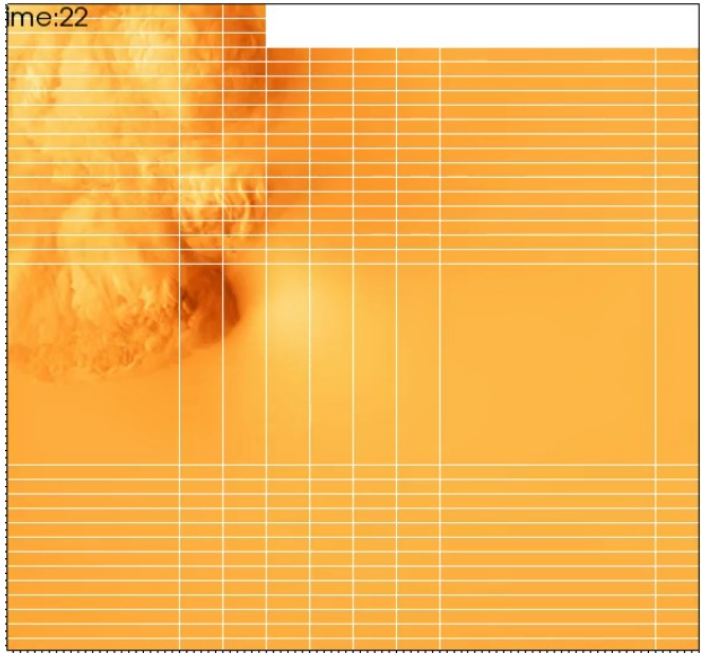

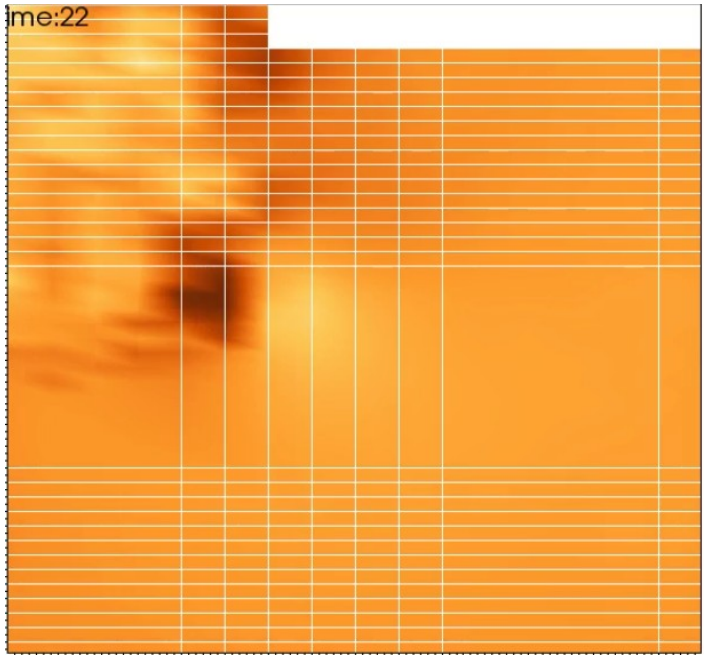

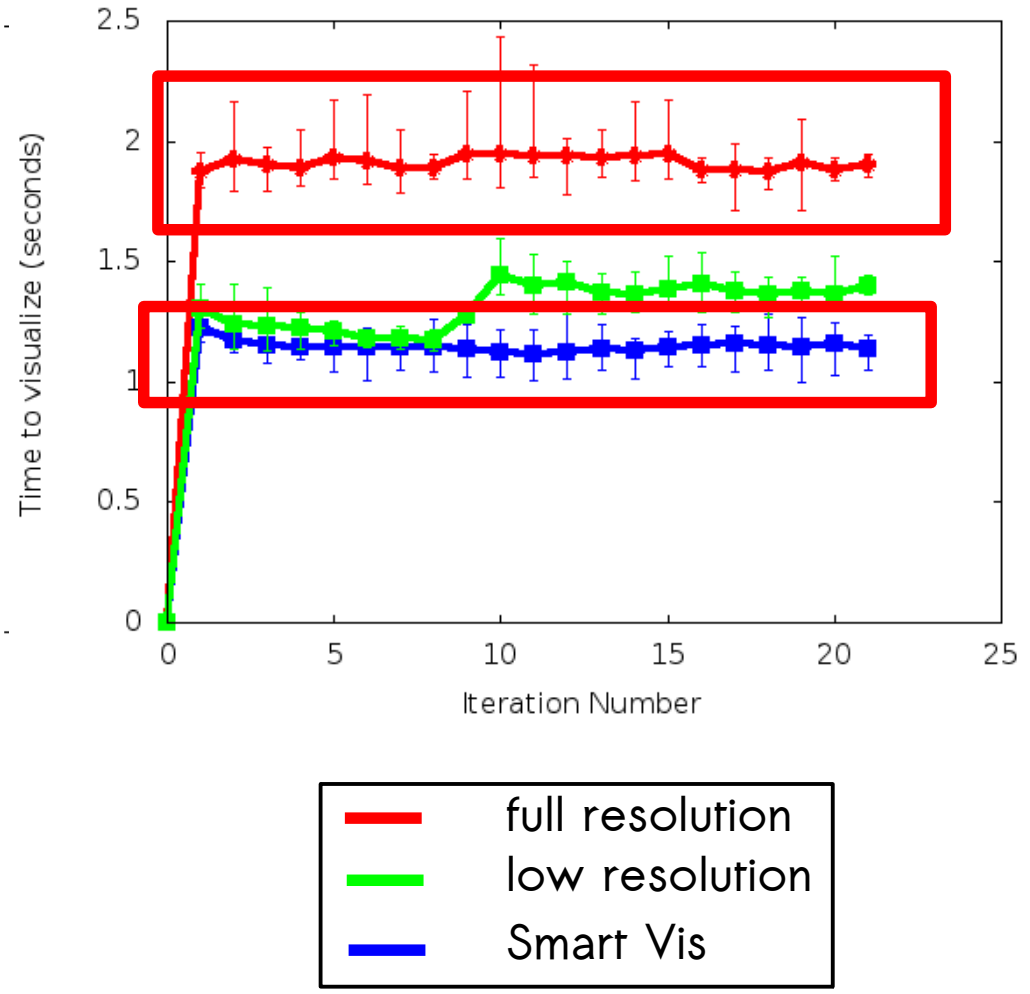

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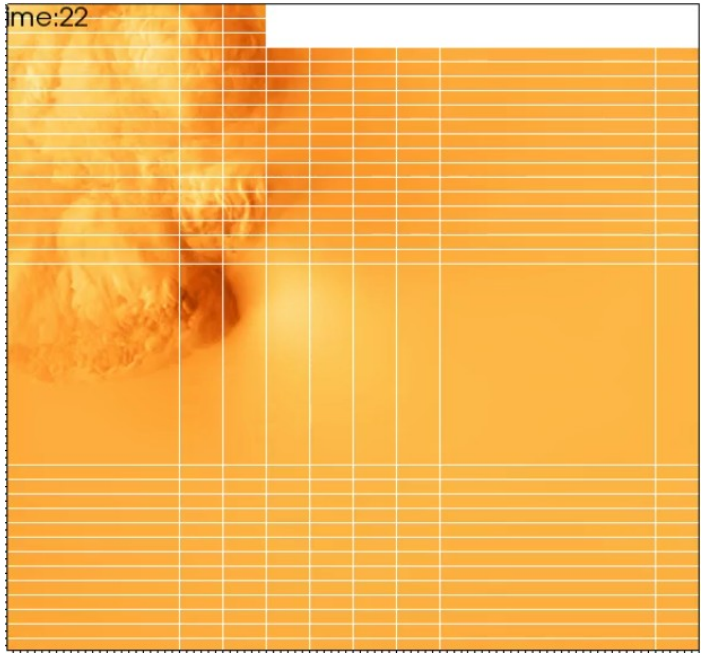

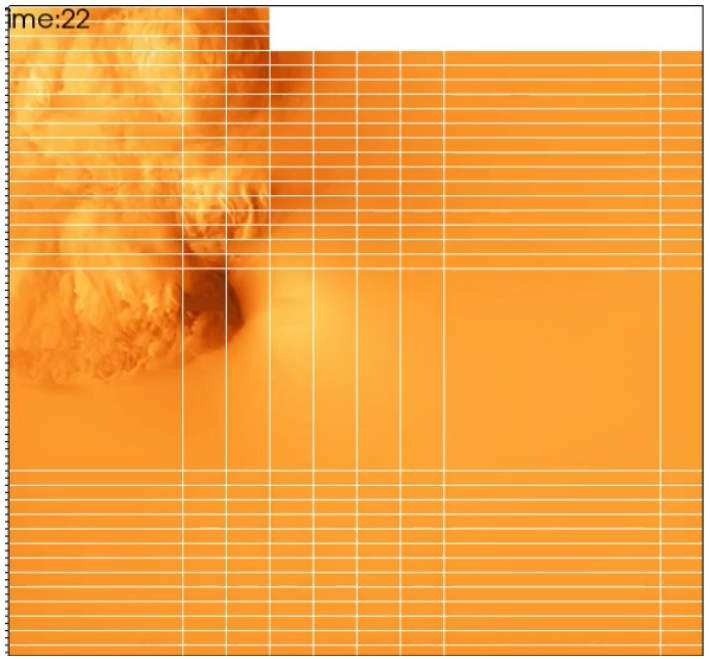

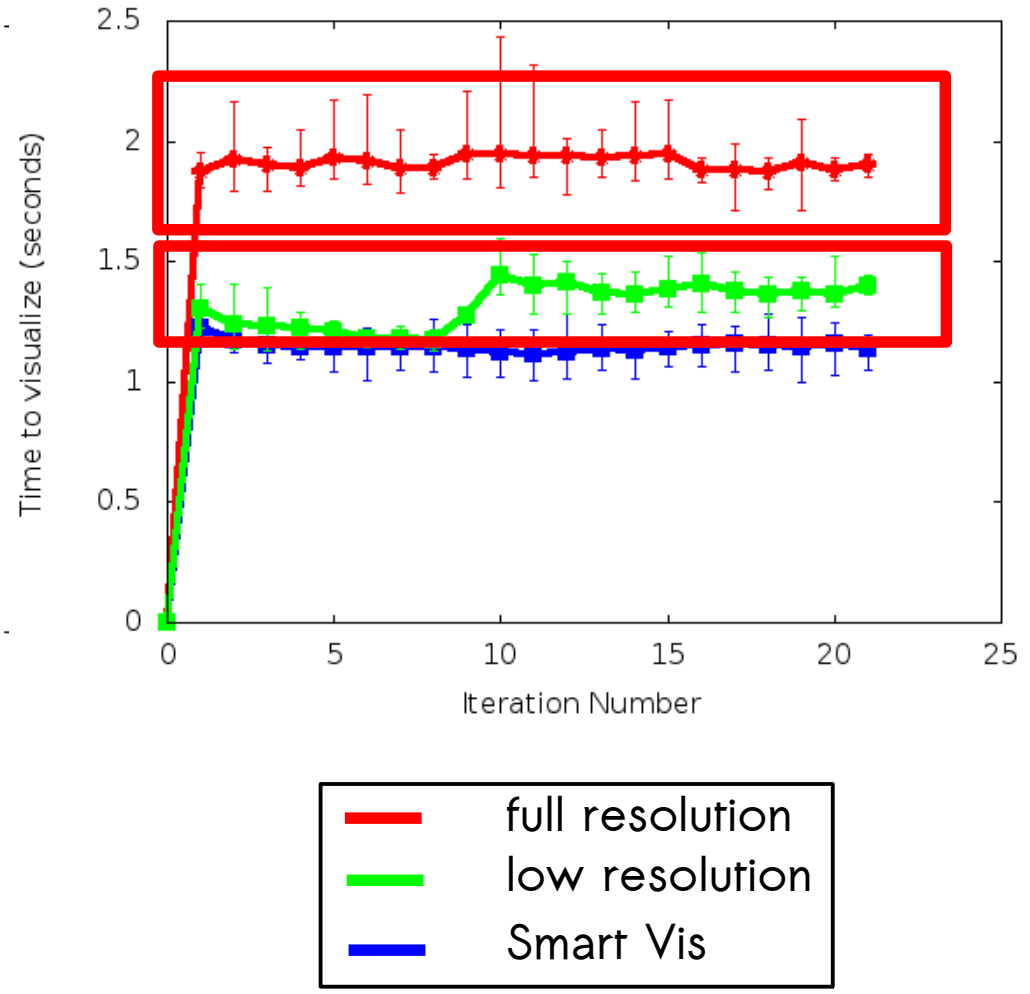

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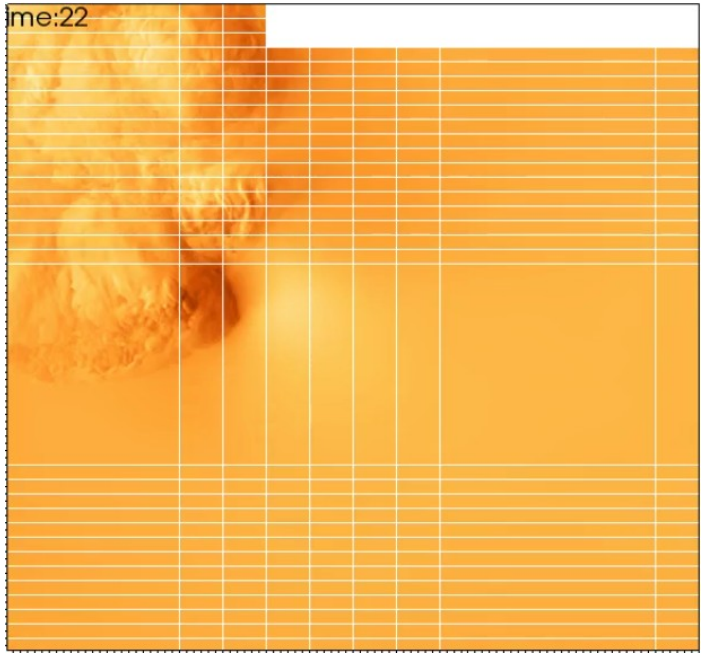

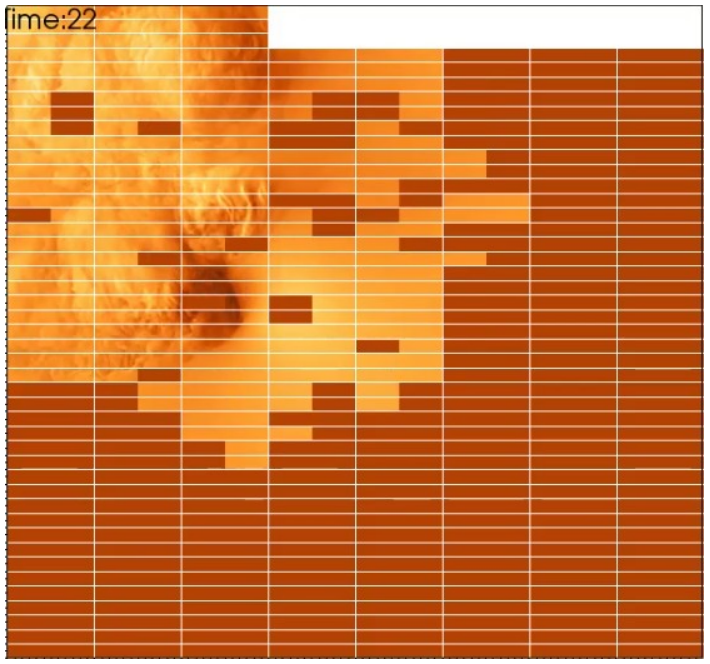

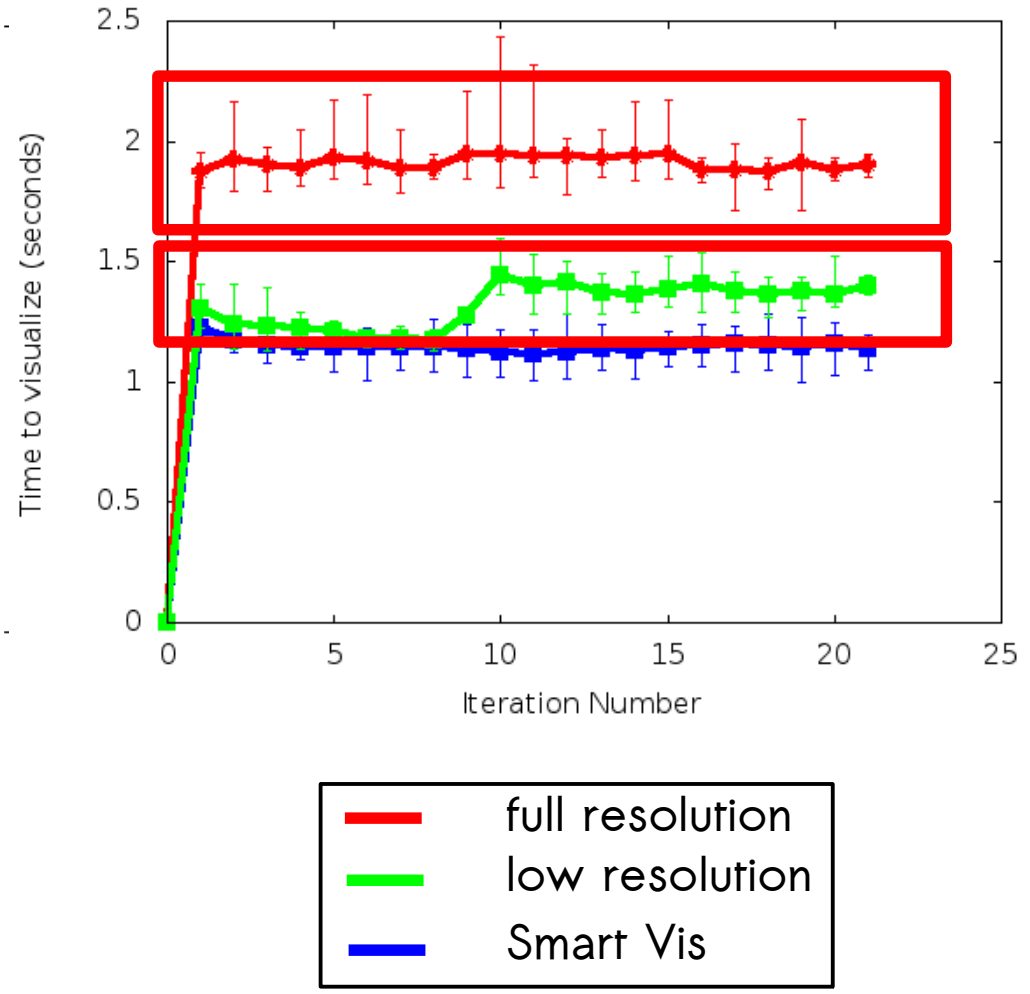

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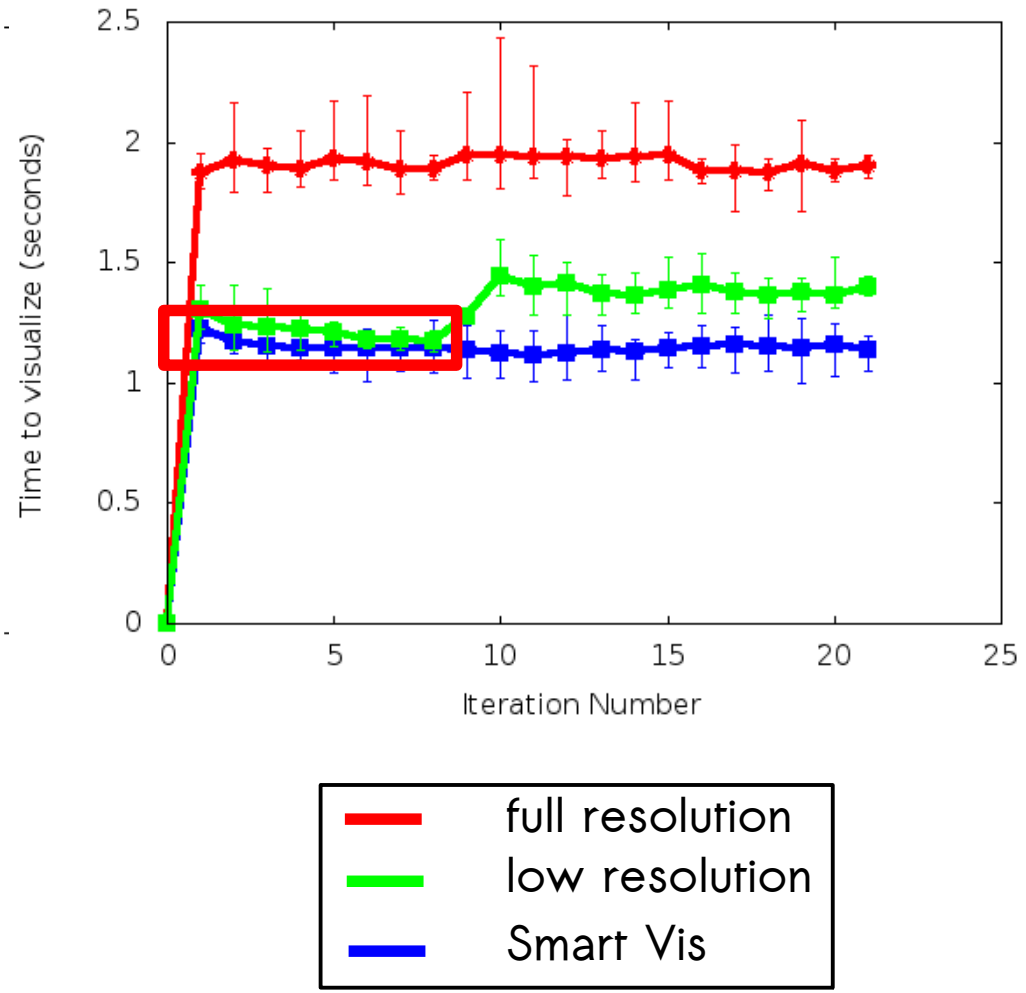

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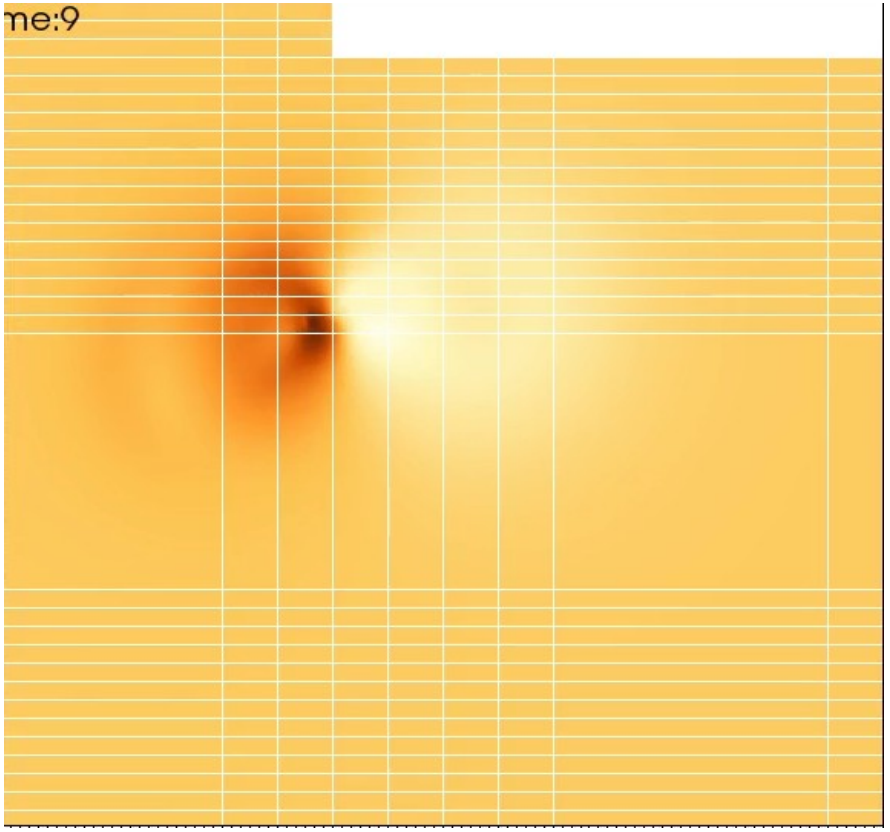

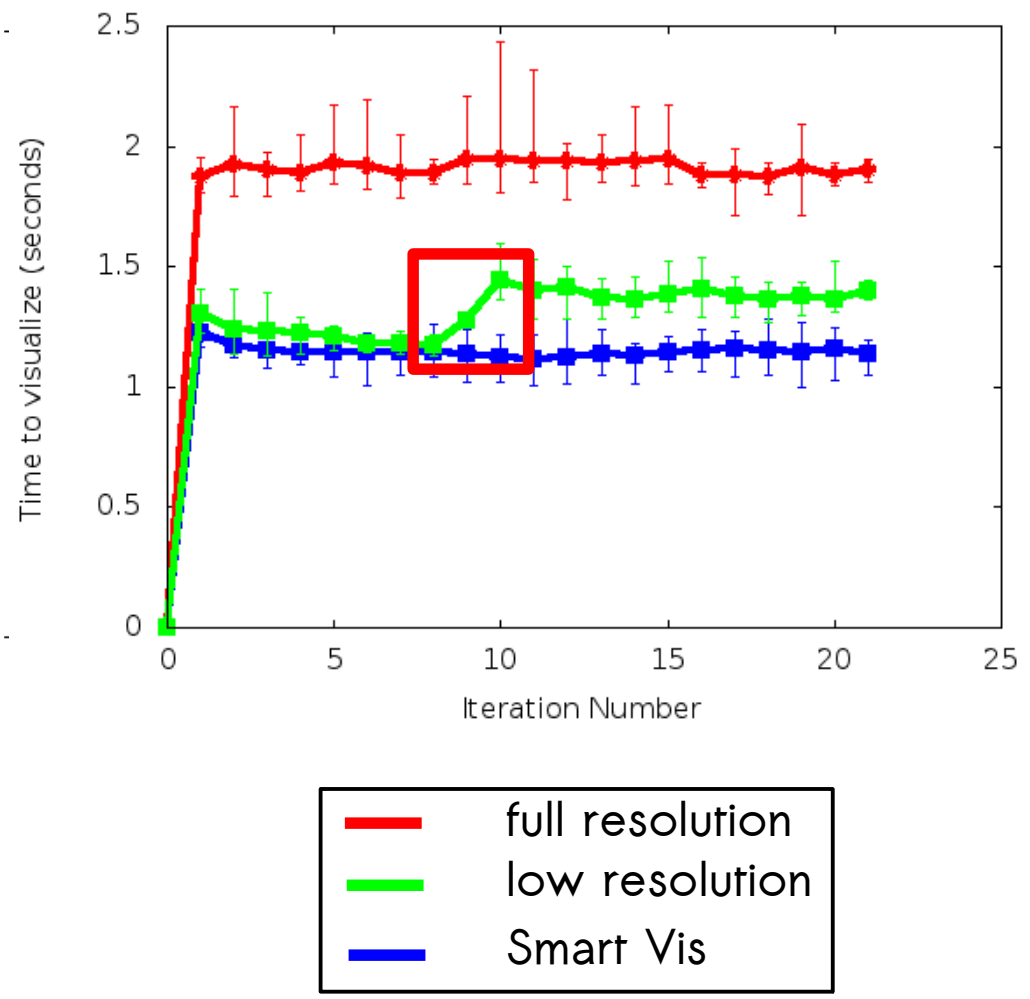

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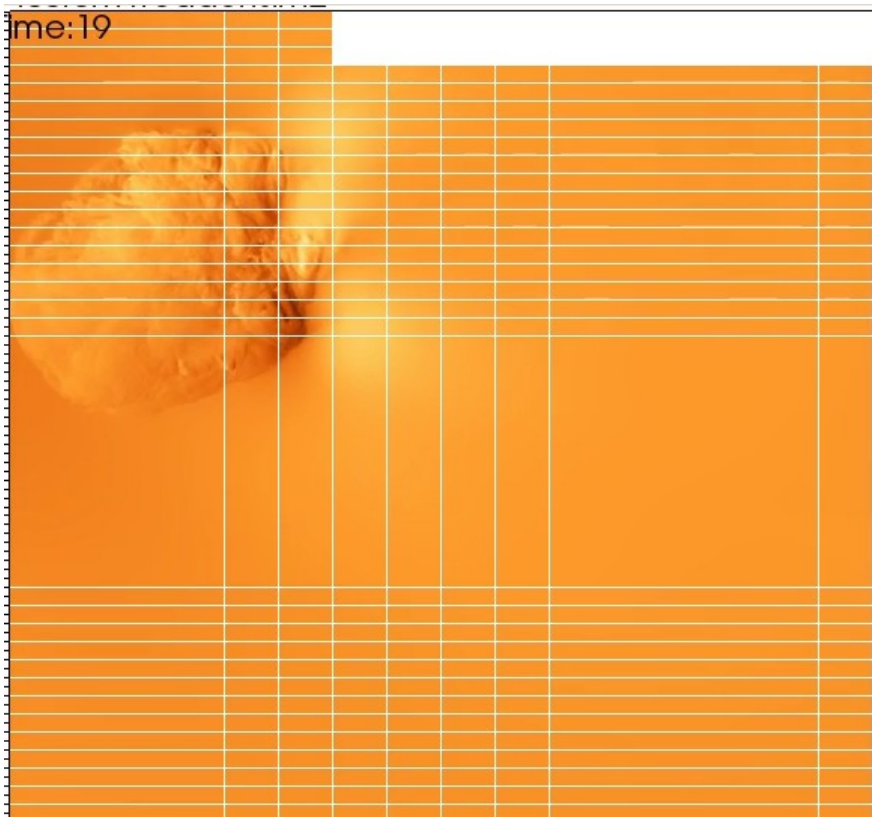

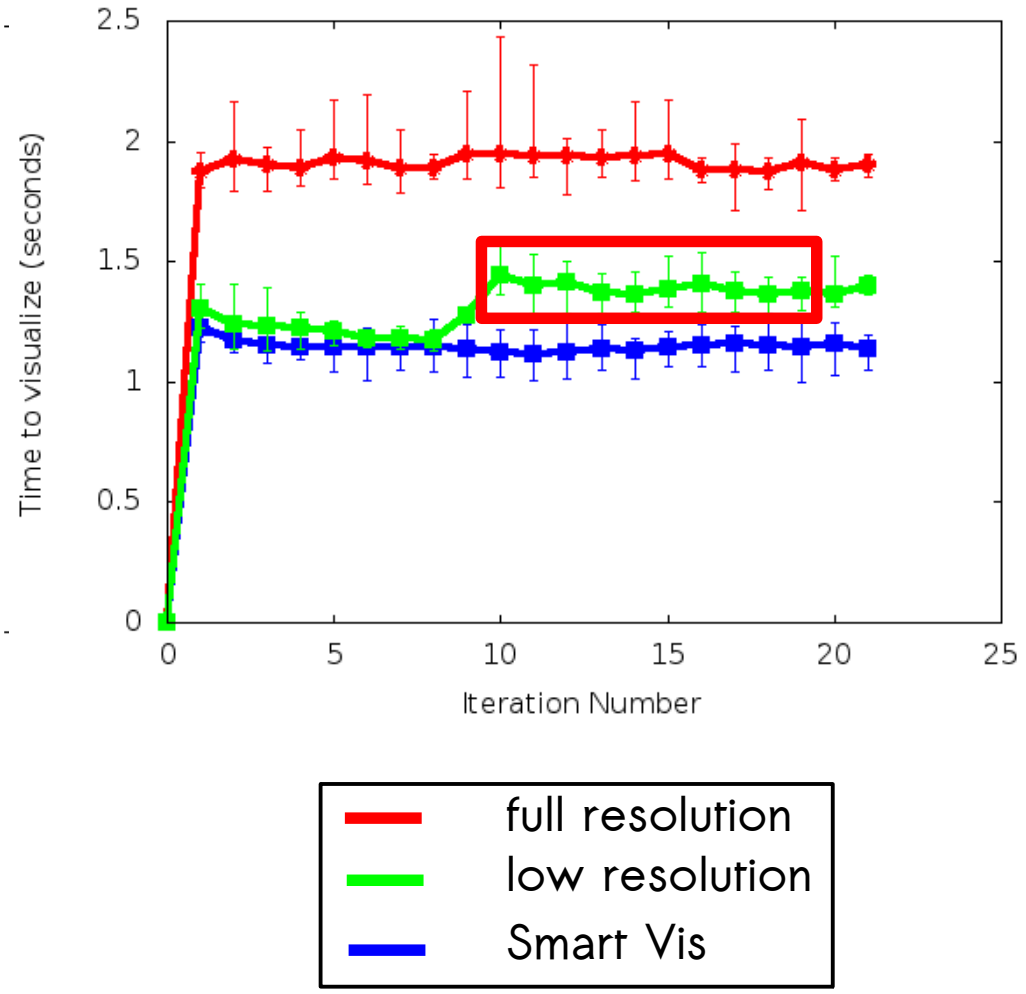

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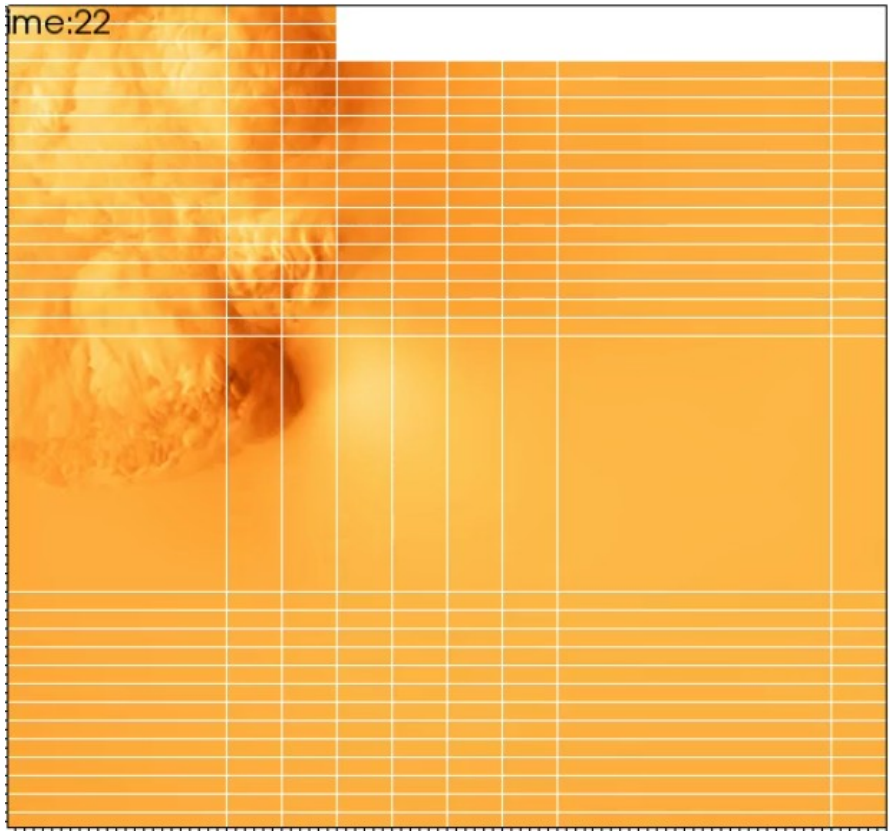

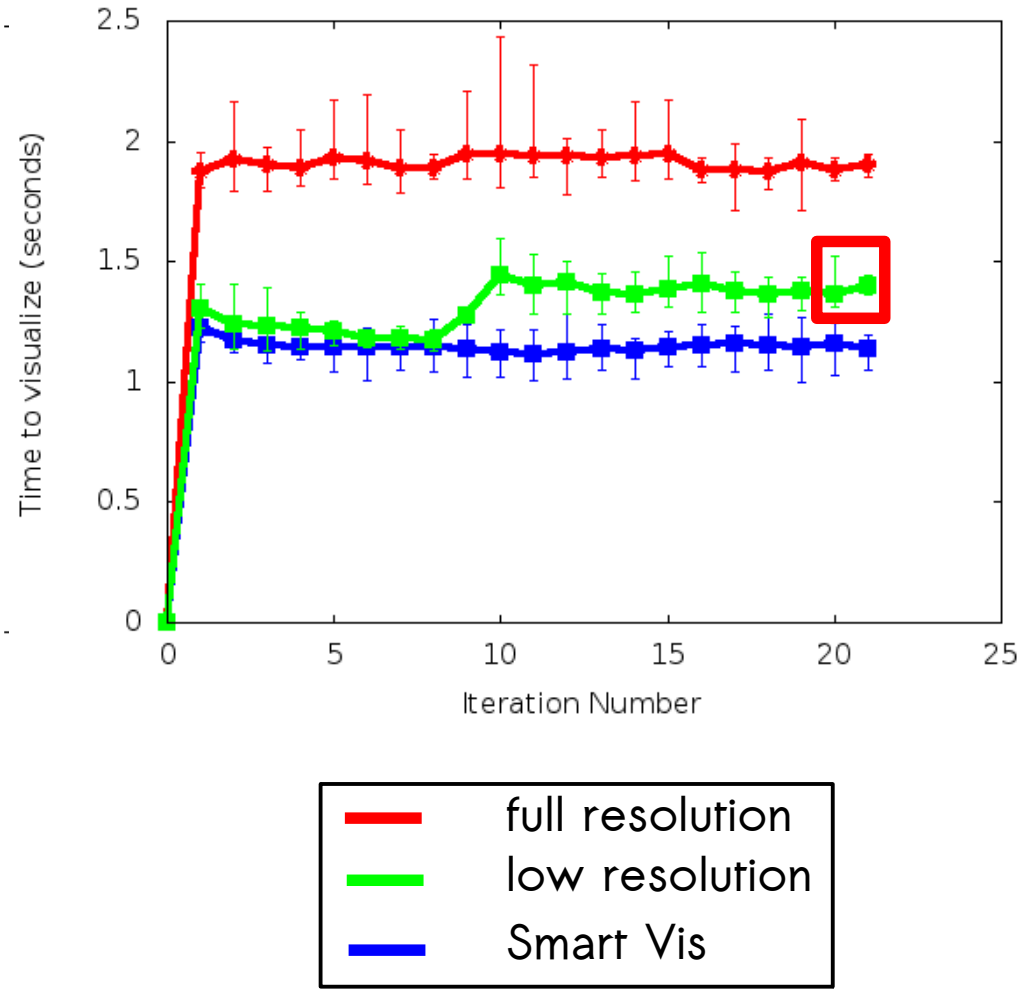

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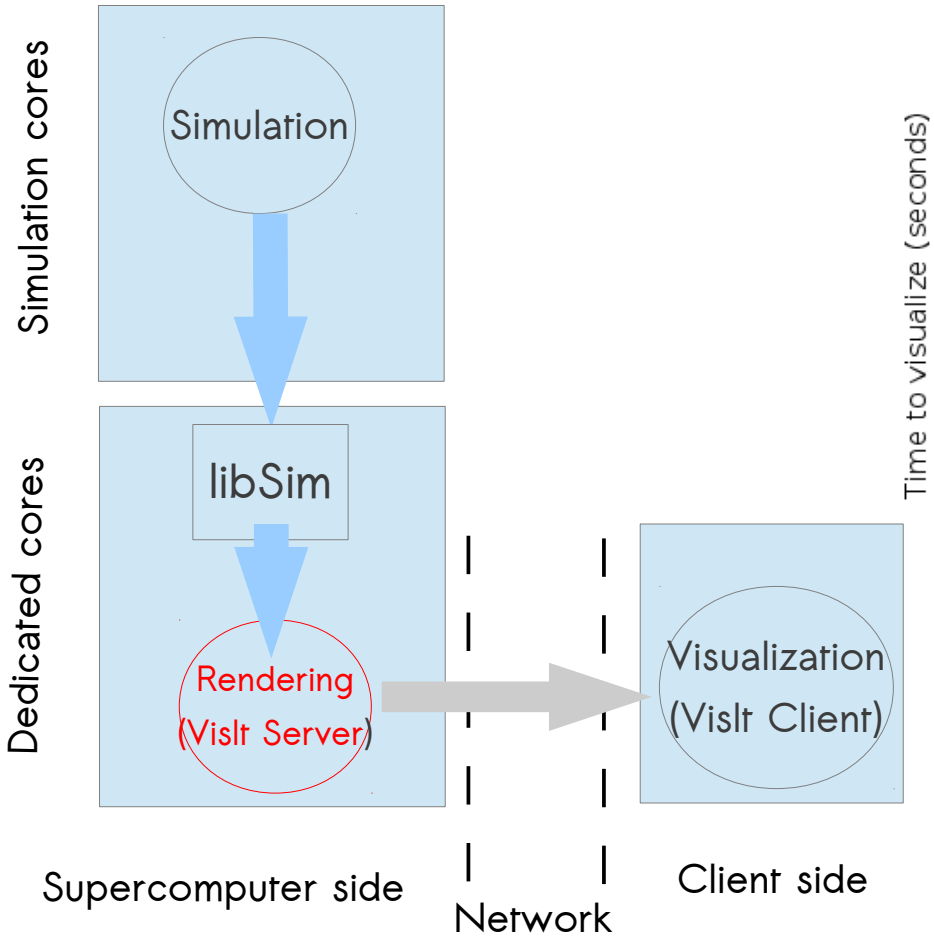
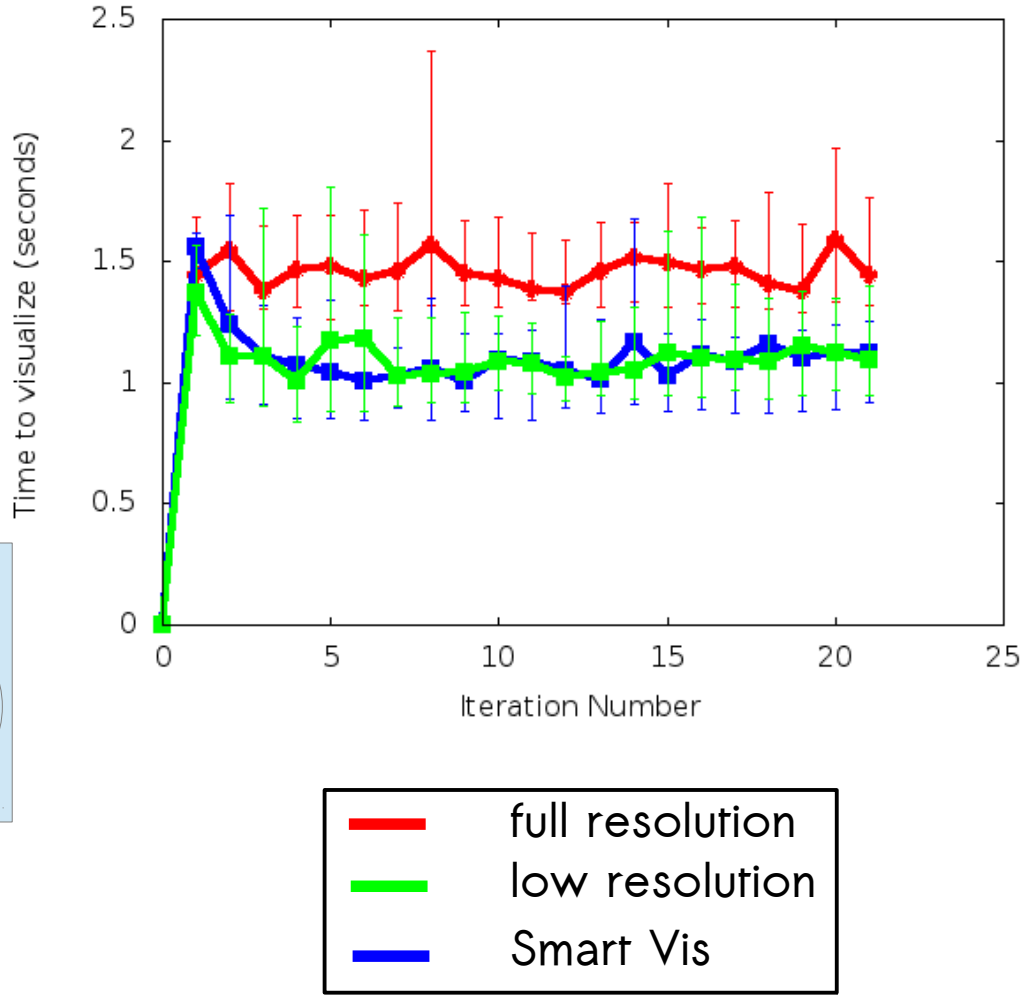
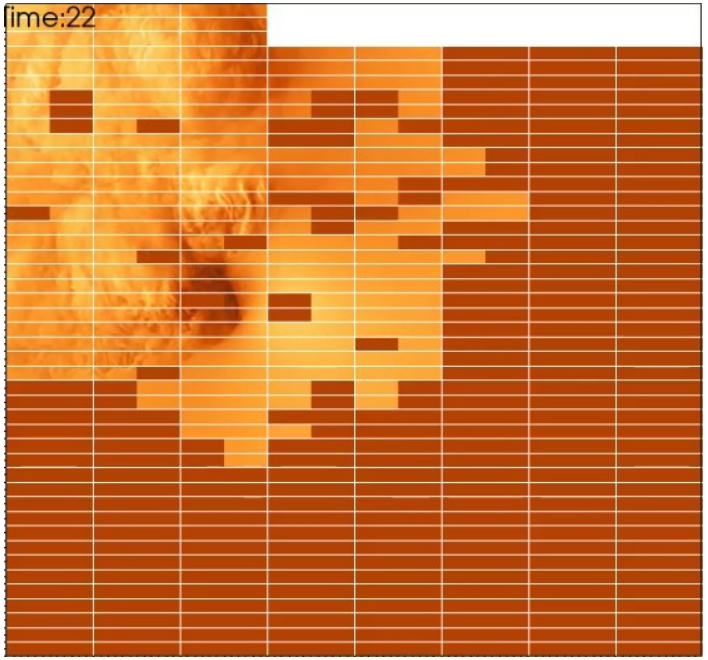


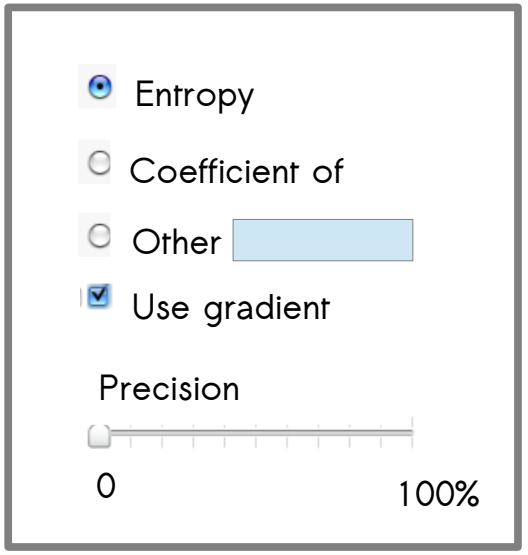


VisIt Scalable Rendering

Gaining the Trust of Scientists

- Provide a window to show filtered areas
- Implement a VisIt plug-in with :
  - A slider to control the metrics
  - A list of available metrics
- Provide a metric to calculate the QoV
  - Objective metrics (ex MSRE, MSR) : bad metrics
  - Working with image processing researchers on a best metric





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Conclusion

- Defined a semantic based on variation in the data
- Propose different metrics to automatically detect relevant data
- Integrate it in existing ISV framework in a complete transparent way
- Provide a gain up to 40% with no considerable loss in quality of visualization

On going work

- Implement a slider to control the metrics as a plug-in in VisIt
- Propose a metric to calculate the quality of visualization QoV => Hard to use an objective metric
- Validation tests at larger scale on BlueWaters are being conducted